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Office Memorandum • UNITED STATES GOVERNMENT

TO : Acting Chief, Engineering Branch
THRU : Acting Chief, Plant Engineering Section
FROM : [redacted]

DATE: 14 August 1951

50X1

SUBJECT: DAQ Radio Direction Finder Capability

2958

1. On Monday, 13 August 1951 at 1230, I called at the office of Lt. R. B. Bodenhammer, Code 297-B, Room 3317, Main Navy, and asked him what was the essential difference between the converted DAQ Radio Direction Finder and the Model SCR-502 of the Signal Corps. Lt. Bodenhammer stated there is little difference between the two systems except that the goniometer in the DAQ will be located in the shack, whereas the goniometer of the SCR-502 must be located in the field near the antennas. The DAQ in its original form uses a broad band crossed loop, which is small and very insensitive, also it is subjected to widely varing inaccuracies. The DAQ using the crossed loop has a very broad null, as it was built for shipboard use, and designed to operate in the presence of large masses of metal.

2. When using the DAQ equipment with the Adcock array and a stable ground plane, there is a large absence of phase distortion caused by the presence of metal masses making it possible to obtain a great reduction in polarization, and an increase in sensitivity and accuracy, far greater than that which can be obtained with the crossover loop under similar conditions. An Adcock antenna will not work on a ship, due to its sensitivity to the presence of metal, and high radiation fields.

3. On inquiring of the transformer difficulties, Lt. Bodenhammer stated that the main problem was to maintain uniform phase shift throughout the band, also the five separate transformers must work together while maintaining the same constant phase relation. The transformers must also match a nominal 36 ohm antenna and a 70 ohm line. Lt. Bodenhammer stated that there is a new type of DAJ equipment now under development which should be ready 1 July 1952. It is a 4 band job that uses 4 sets of antennas, and receivers.

4. The Navy Department, Code 950, loaned me three instruction books pending delivery to us of two copies of each book on the DAQ, the DAJ, and the DAW equipment. Lt. Bodenhammer and Mr. Mathaias of Mr. Thrift's office advised us against the use of the DAW equipment as it was a constant source of trouble.

5. I obtained from Mr. Mathaias a coupling unit developed at NRL that was used in the tropics for over three years. This coupling unit contains the transformer that is causing the production problem. I also obtained the specifications let out for the reproduction of this unit. The coupling unit loaned to us must be returned Tuesday, 14 August.

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6. During a phone conversation Tuesday morning, 14 August, Mr. Mathaias informed me that the specifications we have on hand relating to the DAJ coupling transformer are a duplicate of the DAQ conversion requirements. This brings out the fact that one transformer is not required to cover the entire band as we were given to believe. Below are requirements as stated in Bureau of Ships Contract Specification Serial No. 70-Ships-A-53, 15 December 1949:

Type 1 antenna coupling network shall function in the specified manner over a frequency range of 1.50 to 3.75 mcs.

Type 2 antenna coupling network 3.75 to 7.50 mcs.

Type 3 antenna coupling network 7.50 to 15.0 mcs.

Type 4 antenna coupling network 15 to 22 mcs.

Therefore, it will be necessary to have four sets of antennas to cover the range of 1.5 to 30 mcs. in the DAQ conversion.

7. Attached are specifications of coupling unit.

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Serial No. 70

SHIPS-A-53

15 December 1949

BUREAU OF SHIPS CONTRACT SPECIFICATION

ANTENNA COUPLING NETWORKS

(FOR NAVY MODEL DAJ-a RADIO DIRECTION FINDER EQUIPMENT)

This specification is for use only with Bureau of Ships Contract_____ (Work Order #800-99332).

1. SCOPE AND CLASSIFICATION

1.1 Scope.- This specification covers antenna coupling networks to be used for coupling the vertical, grounded monopoles of the Adcock arrays of the Navy Model DAJ-a Radio Direction Finder Equipment to balanced twin-coax 140-ohm transmission lines.

1.1.1 Antenna coupling networks whose design involves the use of vacuum tubes will not be considered as fulfilling the requirements of this specification.

1.2 Types.- The antenna coupling networks covered by this specification shall be of the following types, as specified:

Type I - For Navy Model DAL-a, Band One of Navy Model DAJ-a.
Type II - For Navy Model DAM-a, Band Two of Navy Model DAJ-a.
Type III - For Navy Model DAN-a, Band Three of Navy Model DAJ-a.

2. APPLICABLE SPECIFICATIONS, AND DRAWINGS

2.1 Specifications.- The following specifications, of the issue in effect on date of invitation for bids, form a part of this specification:

National Military Establishment Specifications

JAN-P-658 - Packaging and Packing of Electrical Equipment and Spare Parts (Electronic, Electrical, and Electro-Mechanical).

Navy Department Specifications
General Specifications for Inspection of Material.
16E4 - Electronic Equipment, Naval Ship and Shore: General Specification.

(Copies of National Military Establishment specification and Navy Department specifications may be obtained upon application to the Bureau of Supplies and Accounts, Navy Department, Washington 25, D.C., except that activities of the Armed Forces should make application to the Supply Officer in Command, Naval Supply Center, Norfolk 11, Va. Both the title and identifying number should be stipulated when requesting copies.)

Bureau of Ships Radio Specifications
16B16(RE) - Books, Instruction (for Ship and Shore Electronic Equipment).
16D19(RE) - Drawings, Manufacturing, and Microfilm of; and Drawings, Naval Aircraft Installation for Electronic Equipment).

(Copies of Bureau of Ships Radio specifications may be obtained upon application to the Bureau of Ships, Navy Department, Washington 25, D.C. Both title and identifying number should be stipulated when requesting copies.)

2.2 Drawings.- The following drawing, of the issue in effect on date of invitation for bids forms a part of this specification:

Naval Gun Factory Electronics Laboratory Drawing
RW66F228 - Navy Type 62439 Terminal Box for Cathode Follower of Model DAJ-a.

(Copies of Naval Gun Factory Electronics Laboratory drawings may be obtained upon application to the Bureau of Ships, Navy Department, Code 838, Washington 25, D.C.) Both the title and identifying number should be stipulated when requesting copies.)

3. REQUIREMENTS

3.1 Alternate.- The antenna coupling networks described in this specification shall be supplied in accordance with either of the following two alternate methods:

3.1.1 Alternative A.- The antenna coupling networks of each type shall be constructed to enable the random selection of five networks to form a complete installation unit, said installation unit to perform as specified herein. Under this Alternative, Paragraph 3.3.1.1, 3.3.2.1, and 4.2.3.1 shall not apply.

3.1.2 Alternative B.- The antenna coupling networks of each type shall be assembled into groups of six, each group fulfilling the requirements of this specification as to match, etc.. Under this alternative paragraphs 3.3.1, 3.3.2, and 4.2.3 shall not apply.

3.2 Antenna coupling networks covered by this specification shall meet the applicable requirements of Specification 16E4, except as otherwise specified herein.

3.3 Bearing error.- The antenna coupling networks, when installed in a five-element Adcock array of the type employed by the Model DAJ-a direction finder with individual elements of said array having the impedance characteristic specified in paragraph 3.10.2, shall not collectively (summation of error due to the five units) introduce an error in the determination of the bearing of a received radio transmission in excess of one degree.

3.3.1 The phase delay of each antenna coupling network of a given type shall not vary more than one-half of one degree from the mean phase delay of the units of that type (see paragrph 4.3.2). Phase delay referred to herein is the phase delay at any frequency within the band covered by the given type and does not stipulate a phase delay versus frequency characteristic.

3.3.1.1 The phase delay of each antenna coupling network of a given matched set shall not vary more than one-half of one degree from the mean phase delay of the units of that set (see 4.3.2). Phase delay referred to herein is the phase delay at any frequency within the band covered by the set and does not stipulate a phase delay versus frequency characteristic.

3.3.2 The gain of each antenna coupling network of a given type shall not vary from the mean gain of the units of that type by more than one-half of one percent. Coupling gain referred to herein is coupling gain at any frequency within the band covered by given type and does not stipulate a gain versus frequency characteristic.

3.3.2.1 The gain of each antenna coupling network of a given matched set shall not vary from the mean gain of the units of that set by more than one-half of one percent. Coupling gain referred herein is the coupling gain at any frequency within the band covered by the given set and does not stipulate a gain versus frequency characteristic.

3.3.3 The match between any two antenna coupling networks of a given type shall be such as to give a balance not less than 100 to one (40 decibels) when measured as specified in 4.3.2 and 4.3.2.1.

3.4 Coupling gain.- The coupling gain of each antenna coupling unit shall not be less than -10 decibels, when measured as specified in 4.3.3 and 4.3.3.1.

3.4.1 The coupling gain of each type of antenna coupling networks shall be such as to produce a gain versus frequency curve having a rate of charge (slope) not in excess of the following values:

Type I, 3.2 db per megacycle.
Type II, 1.6 db per megacycle.
Type III, 0.8 db per megacycle.

3.5 Output balance.- The antenna coupling networks shall have an output balance of not less than 40 decibels when measured as specified in 4.3.4 and 4.3.4.1.

3.6 Temperature and Humidity.-

3.6.1 Temperature.- The antenna coupling networks shall perform in the specified manner with variation in ambient temperature from -40°C, to +50°C.

3.6.2 Humidity.- The antenna coupling networks shall perform in the specified manner, with variation in relative humidity from 15 percent to 95 percent.

3.7 The antenna coupling networks shall be so constructed as to be readily installed without modification to the Navy Type 62439 Terminal Box for the cathode followers of the Model DAJ-a. The Navy Type 62439 Terminal Box will conform to Drawing RW66F228.

3.7.1 The antenna coupling networks shall be so constructed as to permit plug-in installation of the units.

3.7.2 It is preferred that the unit construction be such that the networks may be plugged into the receptacles now employed for the cathode follower units.

3.7.2.1 Deviation from such a construction must be approved by the Bureau of Ships. Application for approval of proposed deviation must be accompanied by statement showing advantages of said change.

3.8 The controls of all variable elements shall be placed so as to permit adjustment of the unit while installed as operated in the cathode follower box.

3.8.1 Any parts capable of being varied shall be so designed that no change in adjustment shall occur as a result of vibration, shock, temperature variation or humidity variation.

3.9 Means shall be provided to adequately protect the units against lightning damages.

3.10 The antenna coupling networks shall have the specified characteristics when their inputs are connected to the specified dummy antenna, their outputs are terminated by a non-inductive resistance of 140 ohms, and the unit mounted in the specified cathode follower box.

3.10.1 Dummy antennas.- The dummy antenna to be employed in the measurement of coupling network characteristics shall consist of the following elements connected in series: a non-inductive resistance (R_1), a parallel combination of an inductance (L_1) and a capacitance (C_1), a capacitance (C_2). The circuit shall be as shown on figure 5. The values shall be as specified in table I.

Table I - Value of components.

Band	(ohms) R_1	(microhenries) L_1	(micro-micro-farads) C_1	(micro-micro-farads) C_2
I	50	2.90	50.0	133.0
II	50	2.90	50.0	133.0
III	50	1.90	50.0	93.0

3.10.2 DAJ-a antenna impedance.- The impedance of one monopole of each of the adcock arrays of the Model DAJ-a equipments is as shown on figures 1, 2, 3 and 4.

3.10.2.1 Variation of antenna impedance.- The antenna coupling networks shall be so designed to permit the attainment of the requirements of this specification when utilized in the coupling of antennas whose impedance varies from the values furnished by ± 10 percent.

3.11 Type I antenna coupling network shall function in the specified manner over the frequency range of 1.50 to 3.75 mc/s.

3.12 Type II antenna coupling network shall function in the specified manner over the frequency range of 3.75 to 7.50 mc/s.

3.13 Type III antenna coupling network shall function in the specified manner over the frequency range of 7.50 to 15.0 mc/s.

3.14 It is not mandatory that the specified parts be tested in accordance with the referenced specifications. Where parts are not in accordance with the specified parts specification, it shall be clearly demonstrated that an improvement is accomplished and that such substitutions do not preclude the subsequent use of Navy standard parts in effecting replacements. Approval of the Bureau of Ships shall be obtained for the use of parts not in accordance with the requirements of specified specifications. The manufacturer's request for approval by the Bureau of Ships shall be accompanied by shop drawings or plans clearly illustrating the use of the parts.

3.15 Spare parts.- No spare parts shall be supplied. The antenna coupling networks shall be considered expendable item.

3.16 Manufacturing drawings.- Microfilm of manufacturing drawings shall be furnished in accordance with type D, class IV, of Specification 16D19(RE).

3.17 Instruction books.- Adequate instructions for the installation, operation and maintenance of the antenna coupling networks shall be supplied in manuscript form suitable for inclusion in the instruction book of the Model DAJ-a. Said manuscript shall meet all requirements of Specification 16B16(RE) as to content and presentation.

3.18 Workmanship.- The complete antenna coupling networks shall be constructed in a careful and workmanlike manner, in accordance with good design practice. The quality shall be first class in every respect and shall be in accordance with Specification 16E4.

4. METHODS OF SAMPLING, INSPECTION AND TESTS

4.1 General.- Sampling, inspection, and tests shall be as specified in Specification 16E4, except as otherwise specified herein.

4.2 Five preproduction models of each type of a complete antenna coupling network (requirements for one complete installation) shall be furnished, unless otherwise specified by the Bureau of Ships. These models shall be designed and constructed in accordance with the requirements of this specification, and shall be representative of the type of workmanship and the physical and electrical characteristics and performance of the antenna coupling networks the contractor intends to furnish. The design and construction of these models shall be such that this antenna coupling networks can be produced in quantities and still maintain the characteristics and performance of the models.

4.2.1 The preproduction models shall be delivered at contractor's expense to the Bureau of Ships or any laboratory or test point designated by the Bureau of Ships, for the conduct of such field and laboratory tests as are necessary for the determination of contractor's conformance with requirements of this specification and for any other tests which may be required in order to determine the suitability of this equipment for general Navy use.

4.2.2 Upon notification by the Bureau of Ships of acceptability of the models submitted, the contractor shall proceed with the manufacture of the antenna coupling networks. Should the field or laboratory tests point out any defects or undesirable divergencies from the specification, the models shall be returned to the contractor at his expense. The contractor shall rectify all divergencies from the specification. If necessary the contractor may be required to resubmit, at his expense, a model emboding the required changes for approval prior to production.

4.2.3 Standard networks for each type.- In order to assure that all antenna coupling networks for a given band are identical in r.f. characteristics so that there will be no need for selection of units for a given installation, and so that any unit may be used as a replacement for any other, one unit for each type shall be arbitrarily chosen as a standard network. The other units of this type shall be then compared with this arbitrarily chosen standard in the performance of the tests specified herein.

4.2.3.1 Standard networks for each matched set.- In order to assure that all antenna coupling networks of a given matched set are identical in r.f. characteristics so that any unit within a set may be substituted for any other unit, one unit of each set shall be arbitrarily chosen as a standard network. The other units of this set shall be then compared with this arbitrarily chosen standard in the performance of the test specified herein.

4.3 Preproduction tests.-

4.3.1 General.- The antenna coupling networks are designed to operate in units of five, matching the Adcock arrays of their respective frequency bands. The intent of the design of these coupling networks is to match the output of the Adcock monopoles to the balanced twin-coax transmission lines of the system, maintaining the phase and amplitude characteristics of the received signals. The prime design criteria are the bearing errors introduced by the coupling networks, the loss of signal strength due to the employment of said units, and the maintenance of a balanced output feeding the twin-coax transmission lines. The following tests are the minimum necessary to determine the effectiveness of design and construction in the attainment of the desired characteristics. The Bureau of Ships reserves the right to add to this listing and to delete or modify any test if the need for such addition, deletion, of modification is indicated.

4.3.2 Bearing error.- The equipment shall be submitted to the "match" test specified in 4.3.2.1 to determine whether the requirements specified in 3.3.3 have been met. No individual tests for phase and gain will be required if the requirements of the "match" test are met, as in the meeting of the "match" test the requirements for phase and gain (see 3.3.1 and 3.3.2) will have been included. The test circuit shall be as shown on figure 6.

4.3.2.1 "Match" test procedure.- Connect the coupling network under test to the dummy antenna. Connect the standard network to a dummy antenna. Connect the input terminals of dummy antennas in parallel. Connect the output terminals of the coupling networks in opposition. Connect a low impedance (1-ohm) standard signal generator to input. Connect a balanced-input r.f. measuring equipment (i.e. receiver) to output of combined networks. Establish a reference output, by adjustment of signal generator. Record the signal generator reading, input (1). Disconnect input to dummy antenna of network under test. Readjust signal generator to obtain reference output. Record signal generator reading, input (2). Divide input (1) by input (2). Express in decibels. Repeat this entire test procedure at five uniformly spaced intervals over frequency range of type under test.

4.3.3 Coupling gain.- The coupling gain of the antenna coupling networks is defined as the ratio of the voltage induced in the antenna to the voltage delivered to the transmission line. The test circuit shall be as shown on figure 7.

4.3.3.1 Procedure.- Connect the antenna coupling network to the standard dummy antenna. Connect a low impedance signal generator (1-ohm) to input terminals of dummy antenna. Connect 140-ohm balanced-input receiver to output terminals of network. Establish reference output from receiver. Record signal generator reading, input (1). Disconnect coupling network from receiver. Apply output of signal generator thorugh suitable matching network to receiver. Obtain reference output from receiver by adjustment of signal generator. Record input to receiver, compensating for loss of matching network, input (2). Divide input (2) by input (1). Express in decibels. Repeat this entire test procedure at five uniformly spaced intervals over frequency band of coupling network under test.

4.3.3.2 The data obtained by test specified in 4.3.3.1 shall be plotted on linear graph paper, with the gain, in decibels, as ordinates, and frequency as abscissa. The slope of said curve shall be calculated at point of maximum slope and utilized in determination of meeting of requirements of 3.4.1.

4.3.4 Output balance of networks.- The outputs of the respective antenna coupling networks shall maintain a balance to ground of not less than 40 decibels. The test circuit shall be as shown on figure 8.

4.3.4.1 Procedure.- Connect standard signal generator to input terminals of coupling network. Across the output terminals of the network place two matched 10K ohm resistors in series. From the midjunction of these resistors place 140-ohm resistor to ground. Place receiver input across 140-ohm resistor. Establish a reference output from receiver. Note signal generator reading, input (1). Remove receiver input and 140-ohm resistor from the mid point and connect from one output terminal to ground. Ground the other output terminal. Adjust signal generator level to obtain reference output. Record signal generator reading, input (2). Divide input (1) by input (2). Express result in decibels. Repeat this entire test procedure at five uniformly spaced intervals of frequency range.

4.3.4.1.1 Match of 10K resistors shall be made within frequency range of measurements.

4.3.5 Humidity characteristics.- The "match" test specified in 4.3.2 and 4.3.2.1 shall be repeated at the highest frequency in the range of the type undergoing test while unit is subjected to variation in humidity from 15 to 95 percent.

4.3.5.1 Procedure.- Place two antenna coupling networks, connected as described in 4.3.2.1, in a humidity chamber, at room temperature between 20 to 30°C. with humidity at ambient level. Determine the match between units. Maintain temperature and humidity conditions for a period of 2 hours. Decrease the humidity to 15 percent, maintaining temperature constant. Maintain humidity at 15 percent for period of 2 hours. Increase humidity to 95 percent, holding temperature constant. Maintain 95 percent humidity for period of 2 hours. Reduce humidity to ambient value. Hold for a period of 2 hours. Measure match of units at 15-minute intervals throughout entire cycle.

4.3.5.2 The requirement of a minimum matching ratio of 40 decibels shall be met throughout humidity cycle.

4.3.6 Temperature characteristics.- The "match" test specified in 4.3.2 and 4.3.2.1 shall be repeated at the highest frequency in the range of the type under test while unit is subjected to variation in temperature from -40°C. to +50°C. Humidity shall be held constant for this test.

4.3.6.1 Procedure.- Place two antenna coupling networks, connected as described in 4.3.2.1, in temperature chamber. With the temperature at ambient level between 20°C. and 30°C., and humidity between 40 and 70 percent, determine balance ratio. Maintain said temperature and humidity for period of 2 hours. Lower temperature to -40°C., holding humidity constant within 15 percent. Maintain -40°C. temperature for a period of 2 hours. Raise temperature to +50°C. Maintain +50°C. temperature for period of 2 hours. Lower temperature to ambient level. Hold for period of 2 hours. Measurement of match of units shall be made at 15-minute intervals throughout test.

4.3.6.2 The requirement of a minimum matching ratio of 40 decibels shall be met throughout temperature cycle.

4.4 Production tests.-

4.4.1 The following minimum number of tests shall be performed on each coupling network delivered under this contract:

4.4.2 Bearing error.- The test specified in 4.3.2 and 4.3.2.1 shall be performed on each network.

4.4.3 Output balance.- The test specified in 4.3.4 and 4.3.4.1 shall be performed on each network.

5. PREPARATION FOR DELIVERY

5.1 Equipment.- Equipment shall be prepared for delivery in accordance with Specification JAN-P-658. Equipment shall be given the service type of packing for domestic shipment or shall be packed for overseas shipment, as specified in the contract or order.

6. NOTES

6.1 Design information.- The requirements of this specification have been evolved from the performance of experimental antenna coupling networks developed by Naval laboratories. Upon application to the Bureau of Ships, Code 838, experimental models and information as to the design of these networks will be available for inspection at the Bureau of Ships, Code 838, Room 3315, Navy Department, Washington 25, D.C. Due to their experimental nature, complete fulfillment of requirements is not attained by these models, particularly in regard to ruggedness, temperature and humidity characteristics. However, the electrical performance requirements are essentially met.

6.2 Copies of this specification may be obtained upon application to the Bureau of Ships, Navy Department, Washington 25, D.C. When requesting state title and identifying number and the purpose for which required.